PLS IVU-20 Undulator mechanical design and analyze

Lin Jin, Fei Gao, Chu Chen, Zhiqiang Jiang, Yong Fan, Hanwen Du

Shanghai Institute of Applied Physics, Chinese Academy of Science

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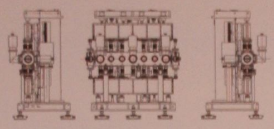
Introduction

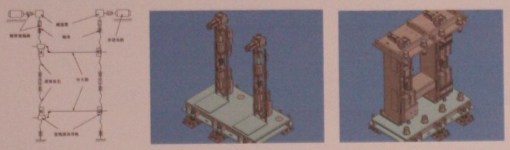
For the purchase from PLS (Puhang Light Source of South Korean), A new type of undulator is developed at SINAP (Shanghai Institute of Applied Physics). It is a 20mm period in-vacuum undulator, to be used to produce hard x-ray with the energy from 5 to 20 keV for Ultra-Small Angle X-ray Scattering beam line.

This machine is composed of four systems: The frame is used to support the vacuum chamber and pumps; the step-motor driving system is for adjusting the magnet field gap; the vacuum system provides the ultimate pressure <7×10-9 Pa without magnets assemblies and girders; and the control system drives the undulator to work under tapered mode with high accuracy and safety.



Taper mechanism in driving system

Step motor gearbox-ball spindle linear guide unit performs the adjustment of the gap of inner beam, on which the magnet array mounted. The gap varies continuously from 5mm to 30mm with step value of 1.0μm. A tangent mechanism is adopted in the design to ensure a large taper dimension.



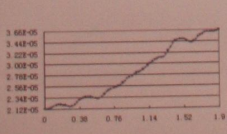
Compensating spring system

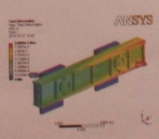
Two types of compensation spring are installed on the top plate and base plate to reduce the load on the driving unit.

Deformation of out-beam

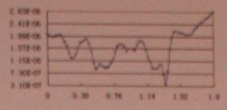
The stiffness of the out-beam will influence magnet field quality. Optimization should be done according to the simulation result of deformation for important components using ANSYS.

The deformation displacement nephogram of the Taper mechanism(without compensating spring system)





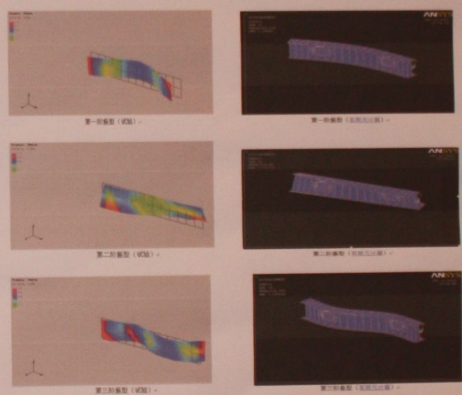
The deformation displacement nephogram of the Taper mechanism （with compensating spring system）



Modal analysis about out-beam

Modal analysis is one of techniques which are used to determine the vibration characteristics of the structure. By modal analysis, we can get eigen-frequency, mode of vibration and effect factor of mode of vibration about the structure. It can provide the basis for the optimal design of vibration fault diagnosis and structural dynamic characteristics. Vibration of out-beam can lead to vibration of inner-beam. Magnet is installed in the inner-beam, and vibration of magnet may change magnetic field distribution and cause oscillation of beam. We can get to know out-beam inherent performance by instrument test and Ansys simulation, then we test and verify the result of modal analysis with modal assurance criterion (MAC). We test and analyze the three frequencies and modes. The results of test are in accord with Ansys calculation, which are the following:

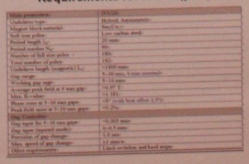
stage	Eigen-frequency	Damp ratio （%）	mode
1	213.2	0.84	The first
2	274.5	1.49	The second
3	517.8	2.65	The third



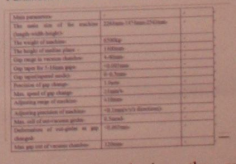
Summary

Not only the mechanical features of the undulator fulfill the requirement from PLS, the parameters of magnet field and vacuum system are satisfied as well.

Requirements for IVU-20(part)



Parameters of PLS IVU-20 made by SINAP (part)



About 12 months were taken for Developing the machine (June,2009-June.2010). In July 2010, finish commission at SINAP, It was shipped to Puhang and installed in storage ring of PLS at spring of 2011. It has been performing for the Ultra-Small Angle X-ray Scattering beam line.